

dimensional metrology

Laser Tracker Standard Update and the NIST 60 m Ranging Facility

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Overview

- Trackers, Laser Radar, & Laser Scanners
- ANSI / ASME B89.4.19 Standard
 - Ranging Tests
 - Volumetric System Test
- Ranging Test Facilities
 - 60 m (200') Cooperative Target Range per B89
 - 65 m (215') Non-Cooperative Target Range
- Volumetric Test Facilities
 - Cooperative Targets per B89
 - Non-Cooperative Range (future)



**HeNe
Interferometer
Tracker**



**ADM
Tracker**



Laser Radar



Laser Scanner

**Single Channel
System**

**Multi Channel
System**

**Cooperative Target
System**

**Non-Cooperative Target
System**

d i m e n s i o n a l m e t r o l o g y

ASME B89.4.19 Laser Tracker Standard

- Designed to Test Cooperative Target Systems
- Focused on mechanical manufacturing (Indoor) environment
- Does not address:
 - Outdoor Environments: Rain; Fog; Wind;...
 - NonCooperative Targets: Concrete; Wood; Dirt;...
 - Motion in the field of view
 - Multichannel Systems (B89 considers pt-pt lengths)
- Status: In Press

B89.4.19: Two Page Spec. Sheet

AN AMERICAN NATIONAL STANDARD

Performance Evaluation of Laser Based Spherical Coordinate Measurement Systems

ASME B89.4.19-200X

DRAFT - WTE
Friday November 25, 2005

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distribute

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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Form 3.1 General Specifications and Rated Conditions

General Specifications and Rated Conditions

RATED CONDITIONS

Measurement envelope

Distance Min. _____ meters Max. _____ meters
Range of horizontal angles _____ degrees
Range of vertical angles _____ degrees

a. Temperature Range

Operating Min. _____ °C Max. _____ °C
Thermal Gradient Limits Max. _____ °C/hr max.

b. Humidity Range

Operating Min. _____ %RH Max. _____ %RH

c. Barometric Pressure Range

Operating Min. _____ mm Hg Max. _____ mm Hg

d. Ambient light - The manufacturer shall identify conditions, if any, under which ambient light degrades specifications.

e. Electrical - The electrical power supplied to a machine can affect its ability to perform accurate and repeatable measurements. This is particularly true when a machine uses some form of computer for any control or readout function.

Voltage _____ V Current _____ A
Frequency _____ Hz Output/Bag _____ V
Max Transient Voltages and duration: _____ V _____ s

f. Probe Type - The probe diameter and reflector type (e.g., cube corner, glass prism) used during performance testing shall be specified.
Diameter _____ mm reflector type: _____

g. Sampling Strategy - The manufacturer shall state the measurement acquisition time (averaging time) and sampling frequency (points per second) to meet specification.
Acquisition time: _____ s Frequency: _____ points/s

LIMITING CONDITIONS

h. Temperature Range

Min. _____ °C Max. _____ °C

i. Humidity Range

Min. _____ %RH Max. _____ %RH

k. Barometric Pressure Range

Min. _____ mm Hg Max. _____ mm Hg

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Form 3.2 MPE Specifications and Test Results

Manufacturer's Performance Specifications & Test Results

Test (positions)	IFM Specifications and Test Results			ADM Specifications and Test Results		
	MPE _{90%}	$\sigma_{90\%}$ Of Spec	Pass	MPE _{ADM}	$\sigma_{90\%}$ Of Spec	Pass
Horizontal (1)						
Horizontal (2,3,4,5)						
Horizontal (6,7,8,9)						
Vertical (1,2,3,4)						
Vertical (5,6,7,8)						
Right Diagonal (1,2,3,4)						
Right Diagonal (5,6,7,8)						
Left Diagonal (1,2,3,4)						
Left Diagonal (5,6,7,8)						
User Selected (1)						
User Selected (2)						
Two Face (1,2,3,4)			+			+
Two Face (5,6,7,8)			+			+
Two Face (9,10,11,12)			+			+
IFM Ranging Ref L (1) =			+			
IFM Ranging Ref L (2) =			+			
IFM Ranging Ref L (3) =			+			
IFM Ranging Ref L (4) =			+			
ADM Ranging Ref L (1) =						
ADM Ranging Ref L (2) =						
ADM Ranging Ref L (3) =						
ADM Ranging Ref L (4) =						
ADM Ranging Ref L User (1) =						
ADM Ranging Ref L User (2) =						
Formula for calculating the MPE or attach MPE specification sheet						

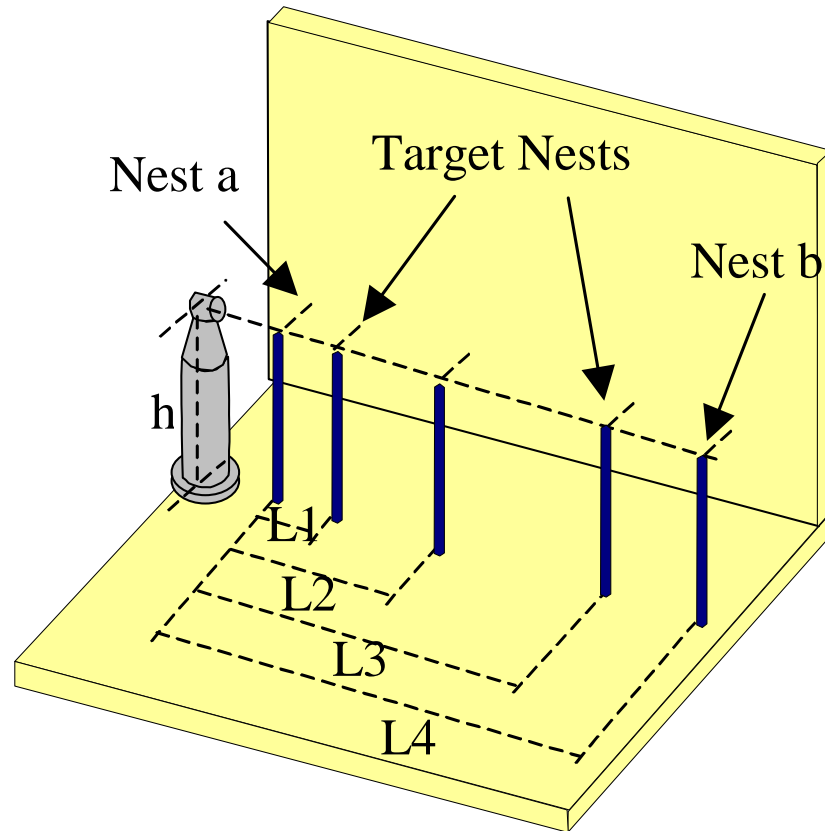
Test Performed by: _____ Date _____ Instrument Serial Number: _____
C_{90%} for IFM System tests: _____ C_{90%} for IFM Ranging tests: _____ IF 1 ≤ C_{90%} ≤ 2 Check □ "Low C_{90%}"
C_{90%} for ADM System tests: _____ C_{90%} for ADM Ranging tests: _____ IF 1 ≤ C_{90%} ≤ 2 Check □ "Low C_{90%}"
Final Test Results (Pass/Fail): _____
Notes: The IFM columns must contain specifications and results for laser trackers with IFM only, the ADM columns must contain specifications and results for instruments with ADM only, and both pairs of columns must contain specifications and results for instruments with both an IFM and an ADM.
* 0 for length system results, Δ for Two-Face results; see sections 7.1 and 7.2
† Two-Face Tests may be performed with either an IFM or an ADM
‡ These results can be: results from long reference lengths, or computed from short reference lengths (see Section 7.3.1), or computed from the laser interferometer calibration certificate (see Section 7.3.1)

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d i m e n s i o n a l m e t r o l o g y

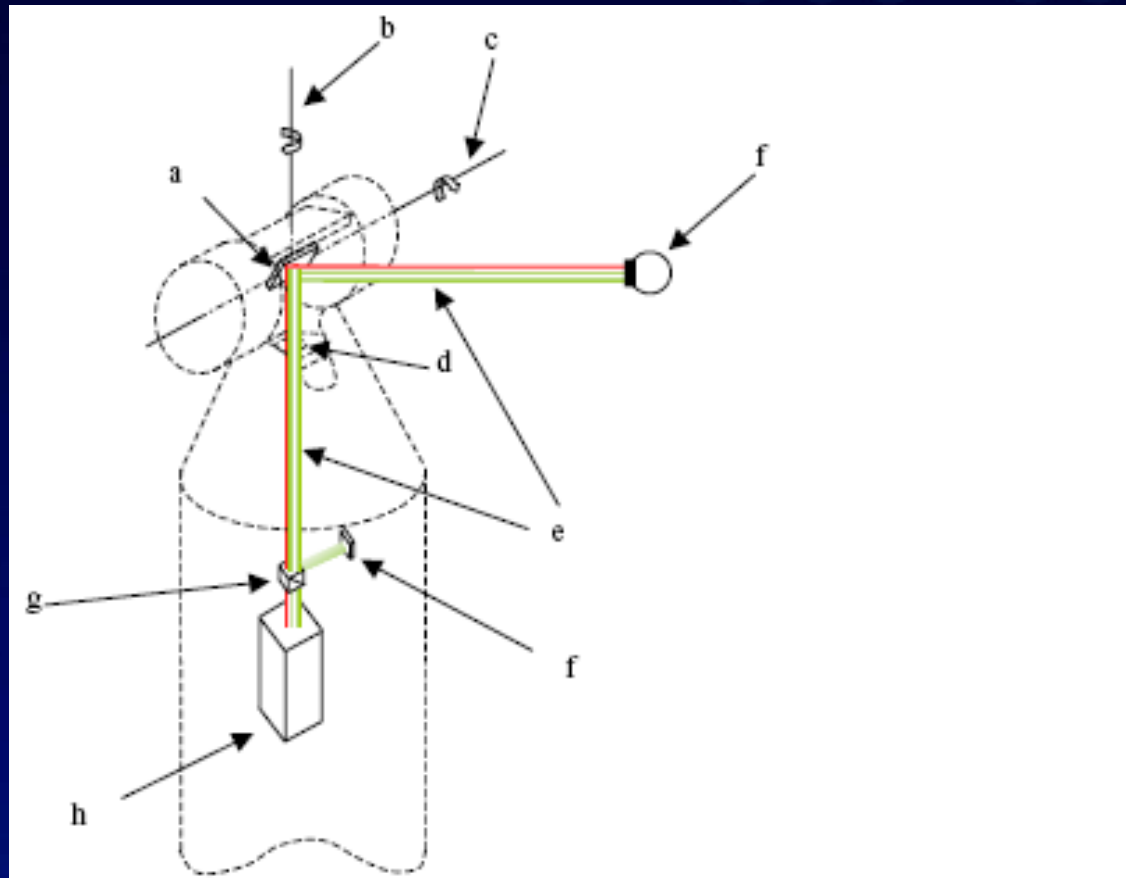
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Ranging Test using 6 Calibrated Lengths (NIST supported calibration)



<i>Position number.</i>	<i>Reference Lengths (R=Maximum Ranging Distance)</i>
<i>1</i>	$L_1 \approx 18\%R$
<i>2</i>	$L_2 \approx 36\%R$
<i>3</i>	$L_3 \approx 54\%R$
<i>4</i>	$L_4 \approx 72\%R$
<i>5</i>	<i>User selected</i>
<i>6</i>	<i>User selected</i>

Volumetric System Tests: Check Optical-Mechanical Alignments

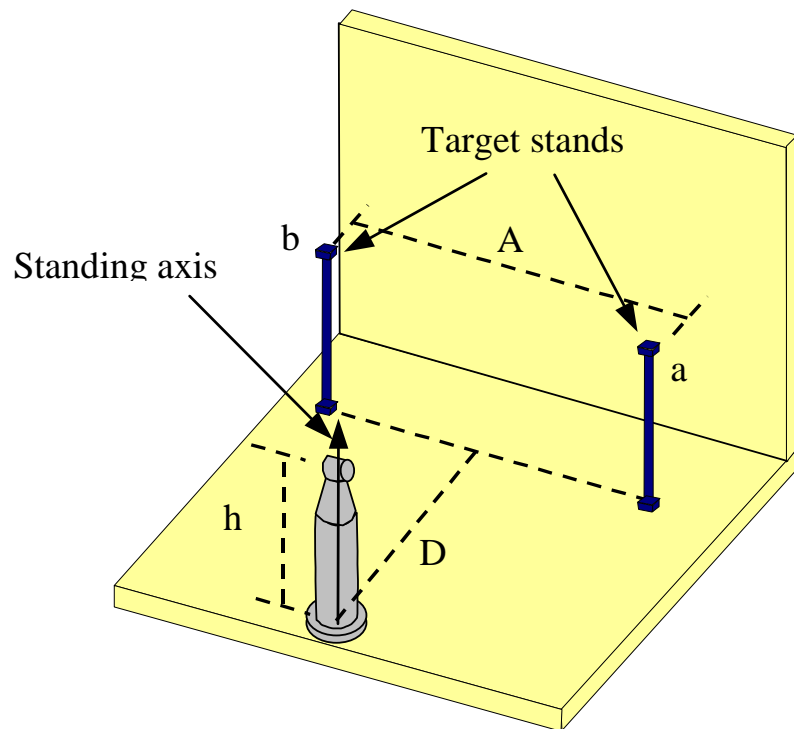


- a. Beam steering turning mirror
- b. Standing or vertical axis
- c. Horizontal or transit axis
- d. Cover plate
- e. Laser beam

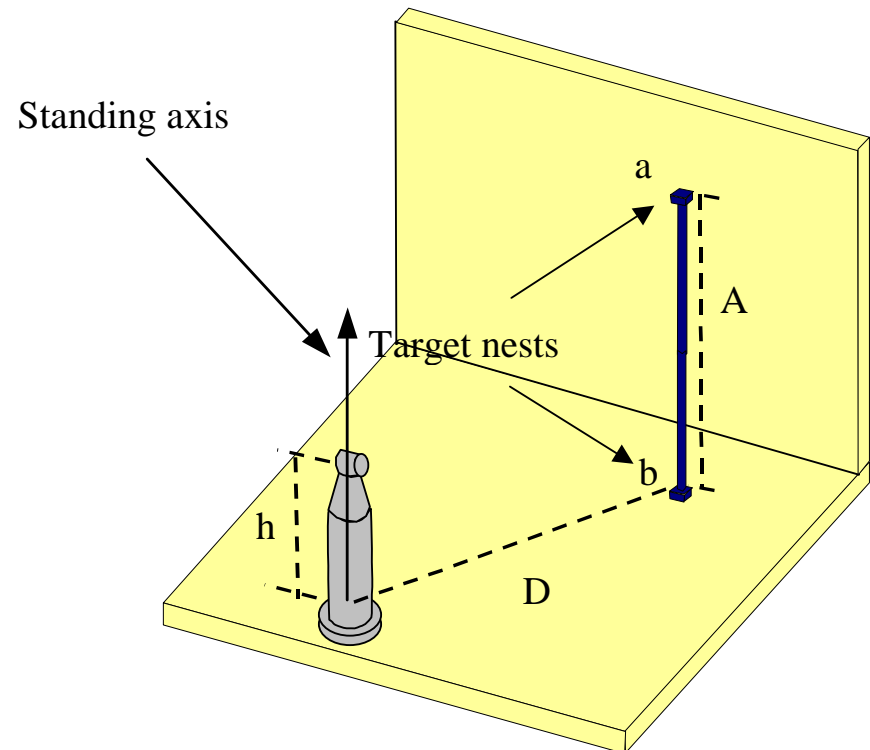
- f. Position Sensing Device (PSD)
- g. Beam splitting interferometer
- h. Laser head
- i. Spherically Mounted Retroreflector (SMR)

Volumetric System Tests

Horizontal Positions

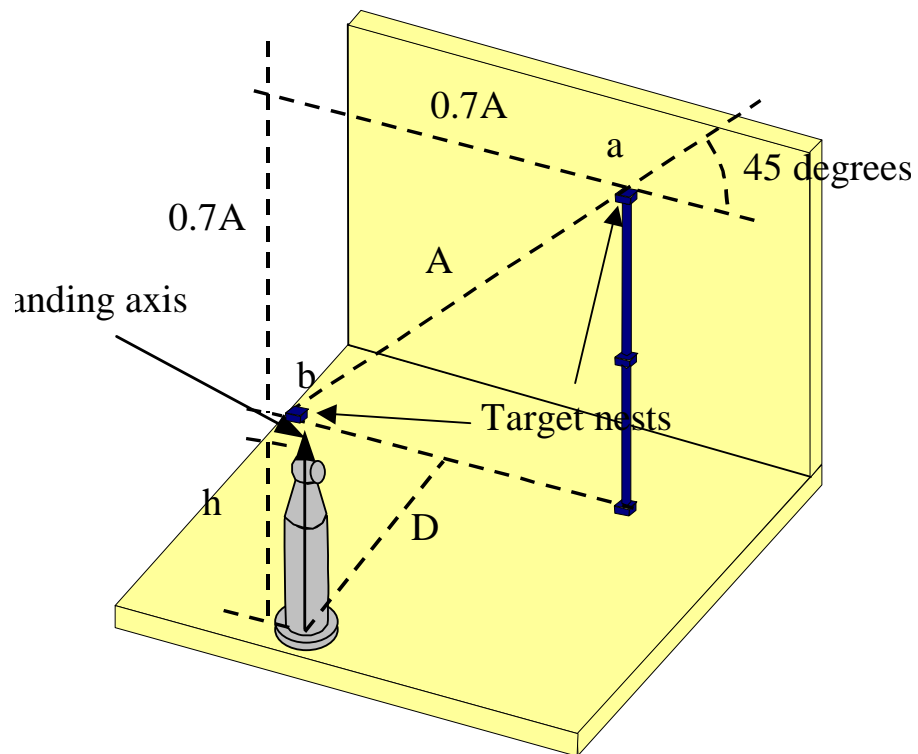


Vertical Positions

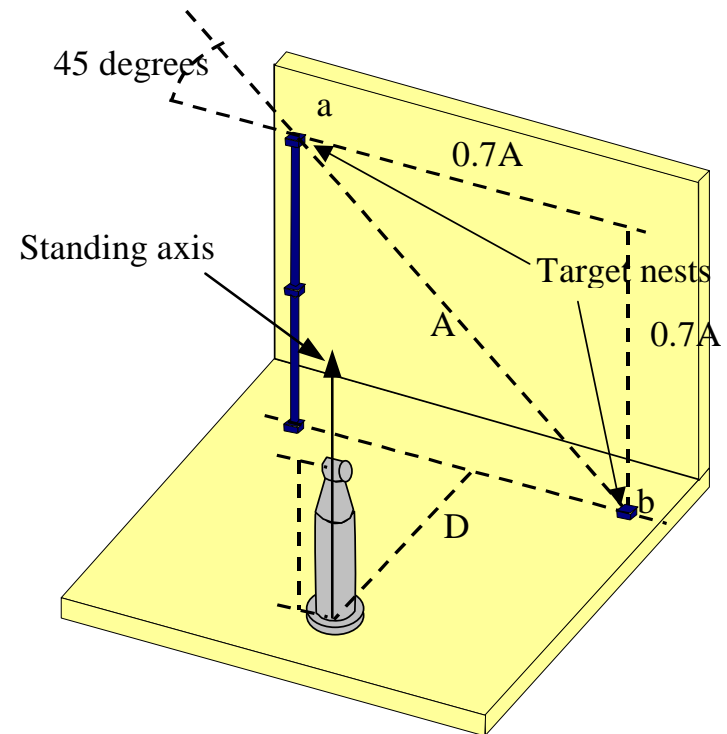


Volumetric System Tests

Right Diagonal Position

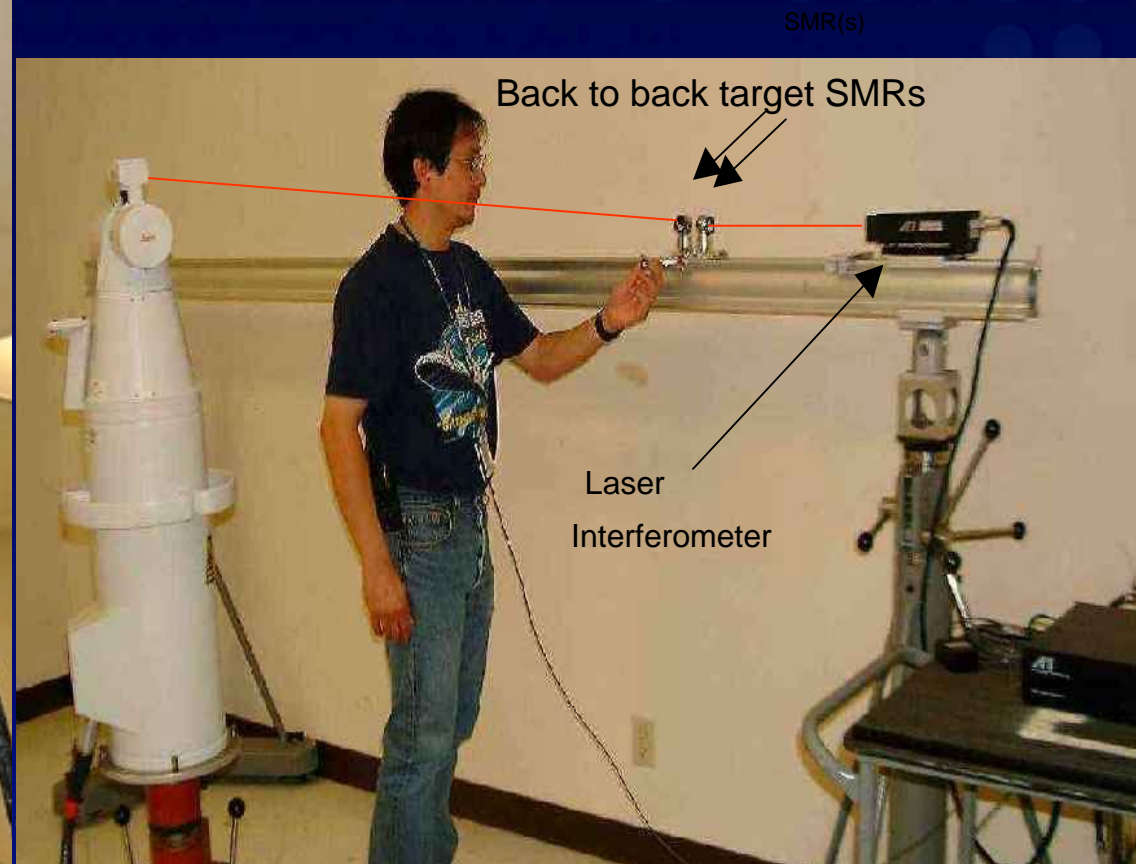


Left Diagonal Position



B89.4.19 Volumetric System Tests: Can be Tested with Laser Rail

(NIST Supported Calibration)



NIST 60 m Ranging Facility



NIST 1D Range Facility

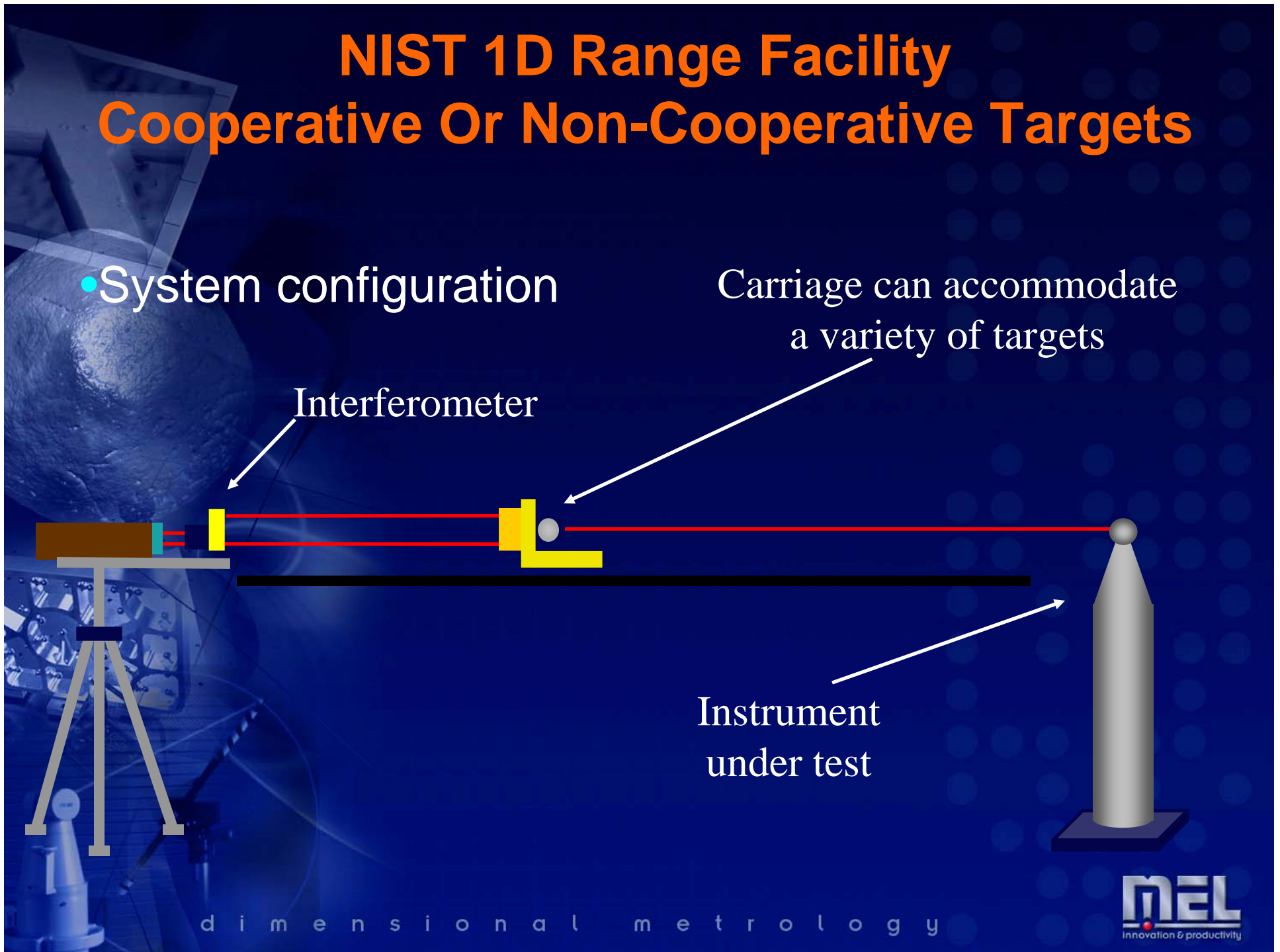
Cooperative Or Non-Cooperative Targets

- System configuration

Carriage can accommodate
a variety of targets

Interferometer

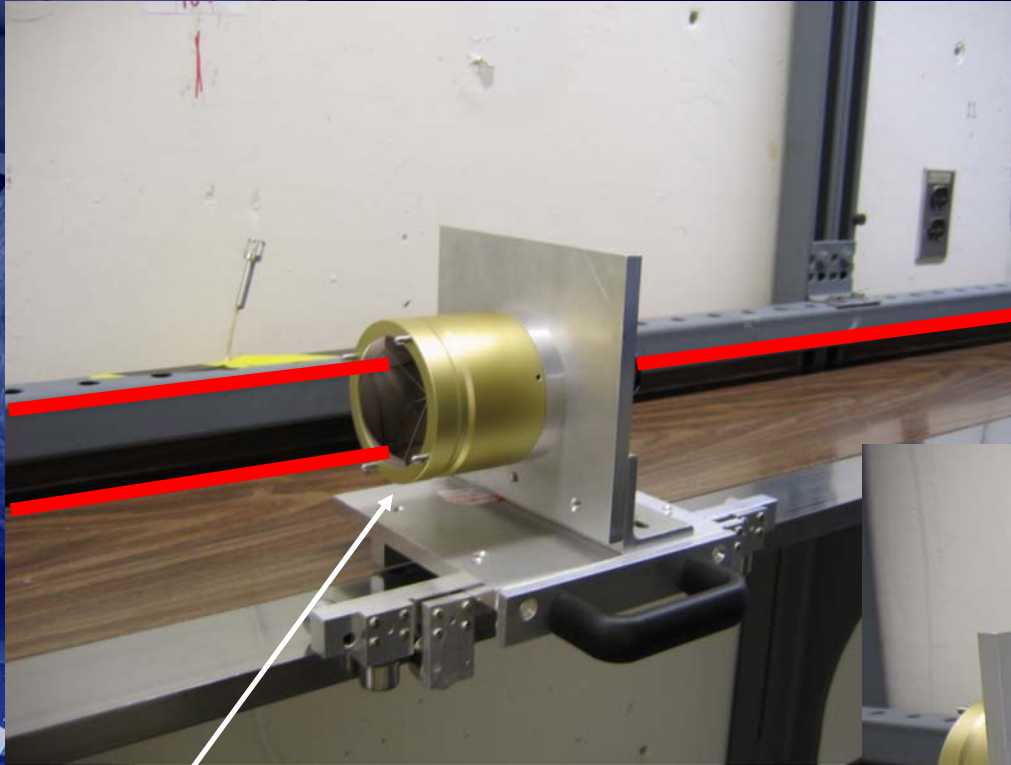
Instrument
under test



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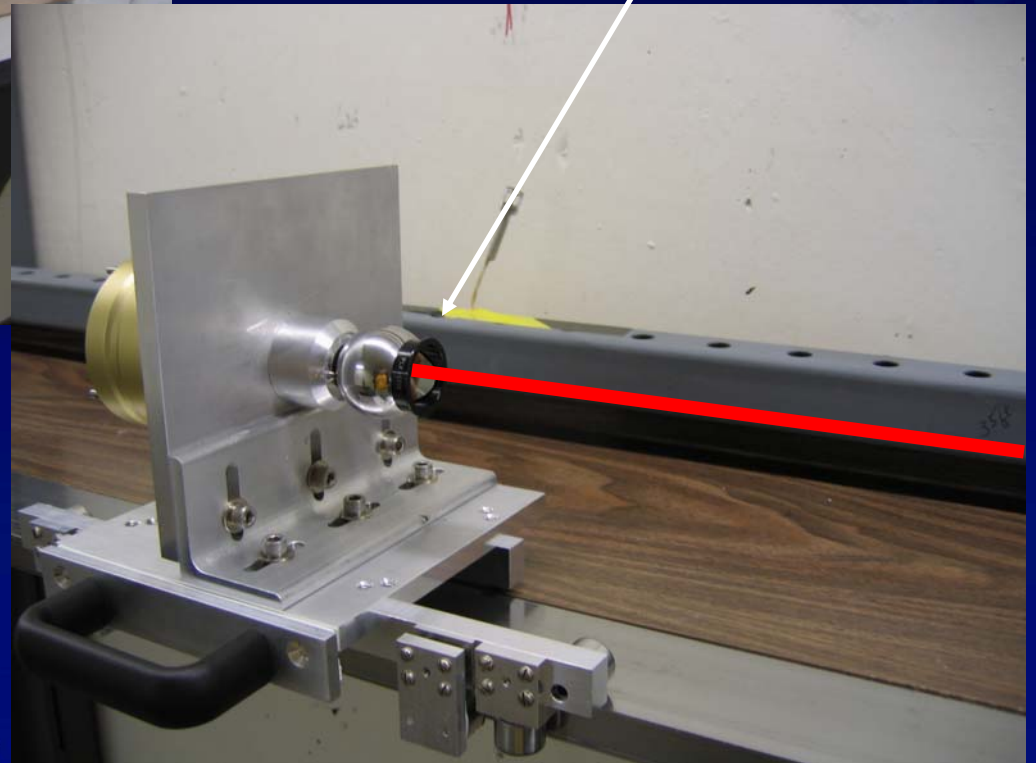
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NIST 1-D Range Facility



Reference retroreflector

Target retroreflector



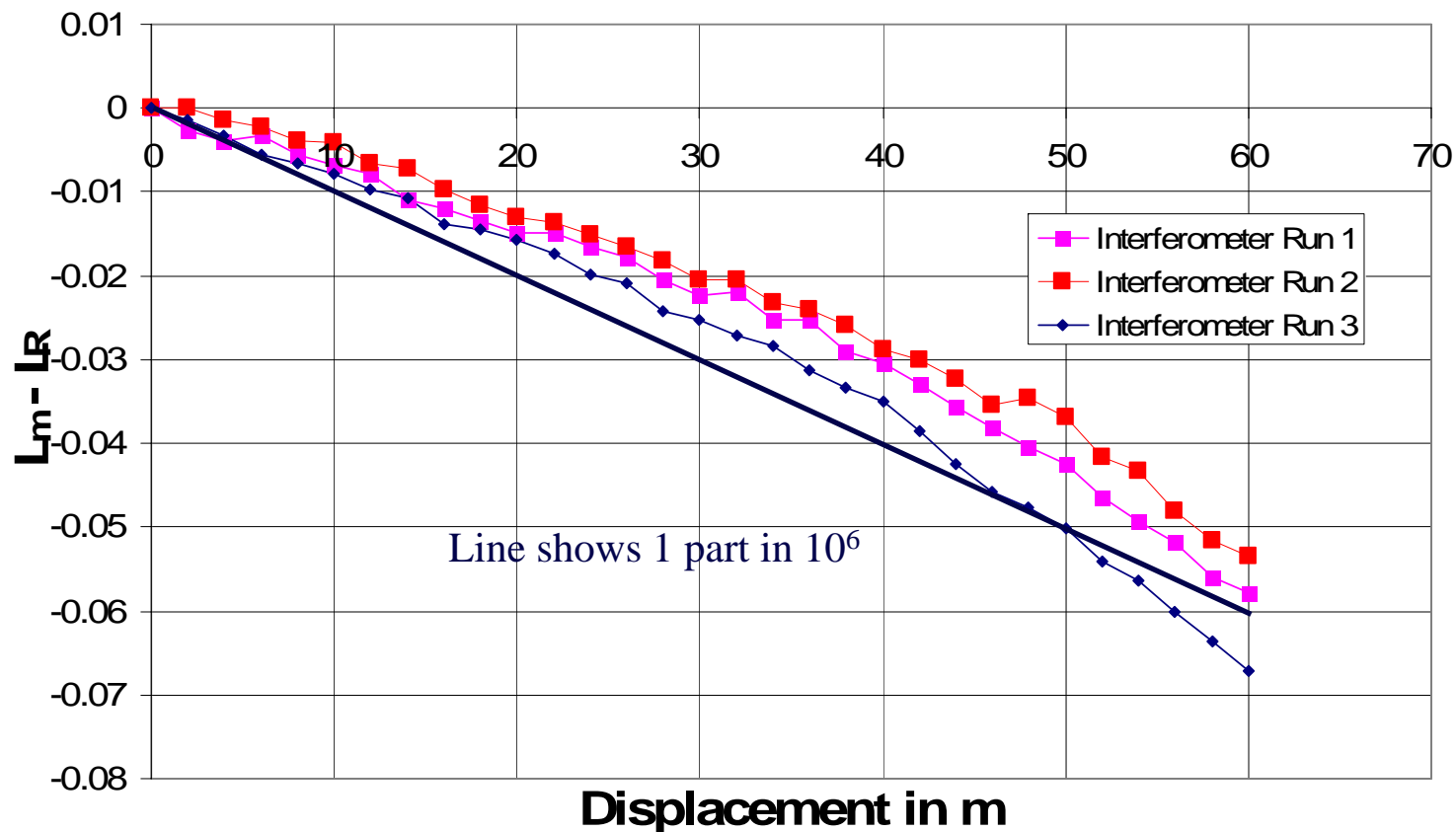
NIST 1-D Range Facility



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NIST 1-D Range Facility

Ranging Test (Dense Data)



NIST 1-D Range Facility

Stability test setup

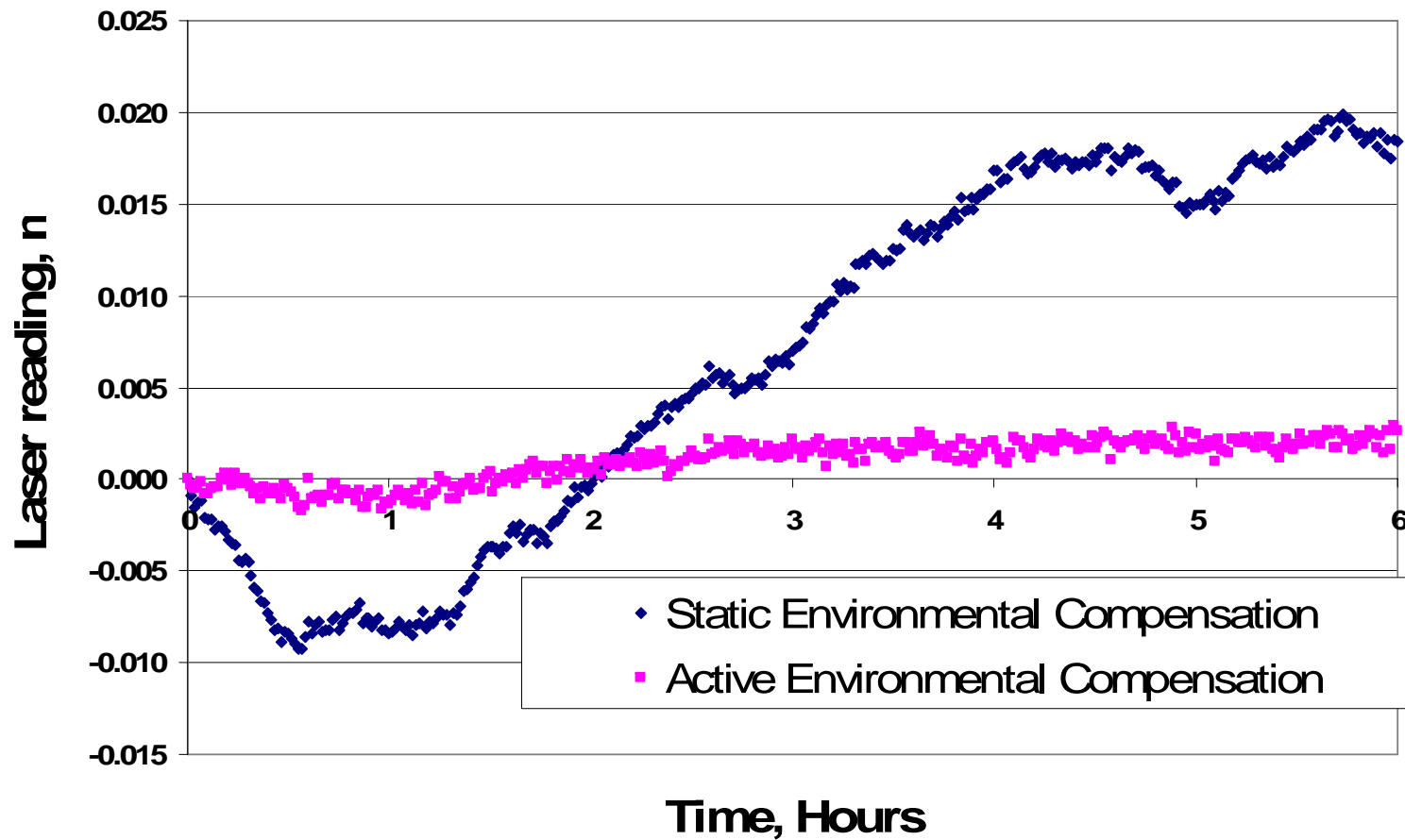
Interferometer
attached to wall

61 m

d i m e n s i o n a l m e t r o l o g y

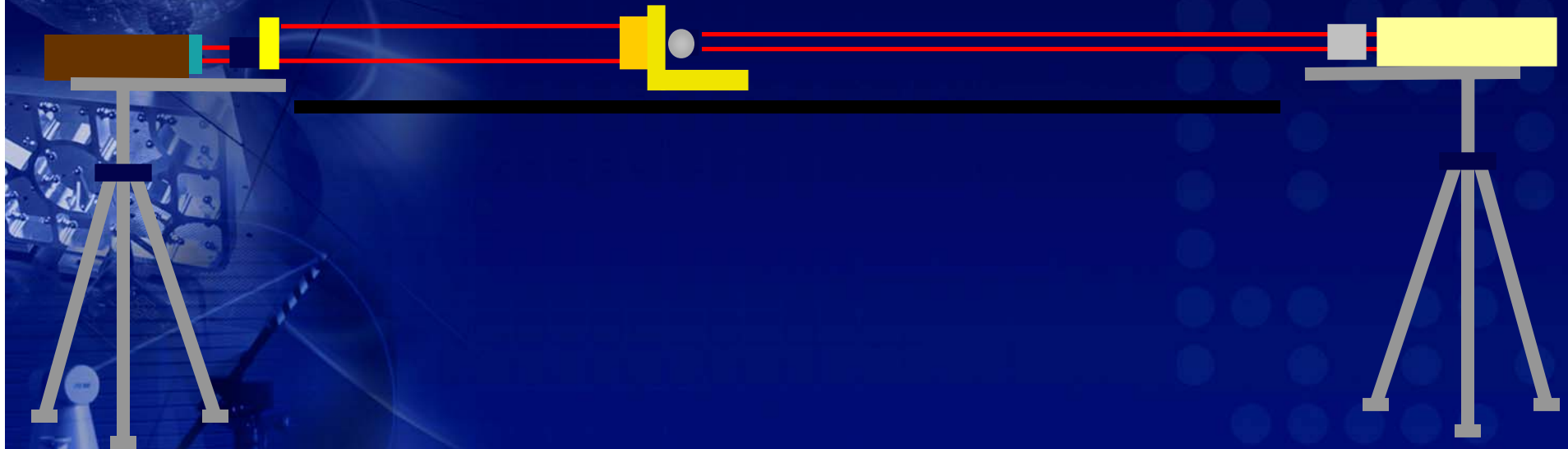
NIST 1-D Range Facility

Rail Stability (61 m)



NIST 1-D Range Facility

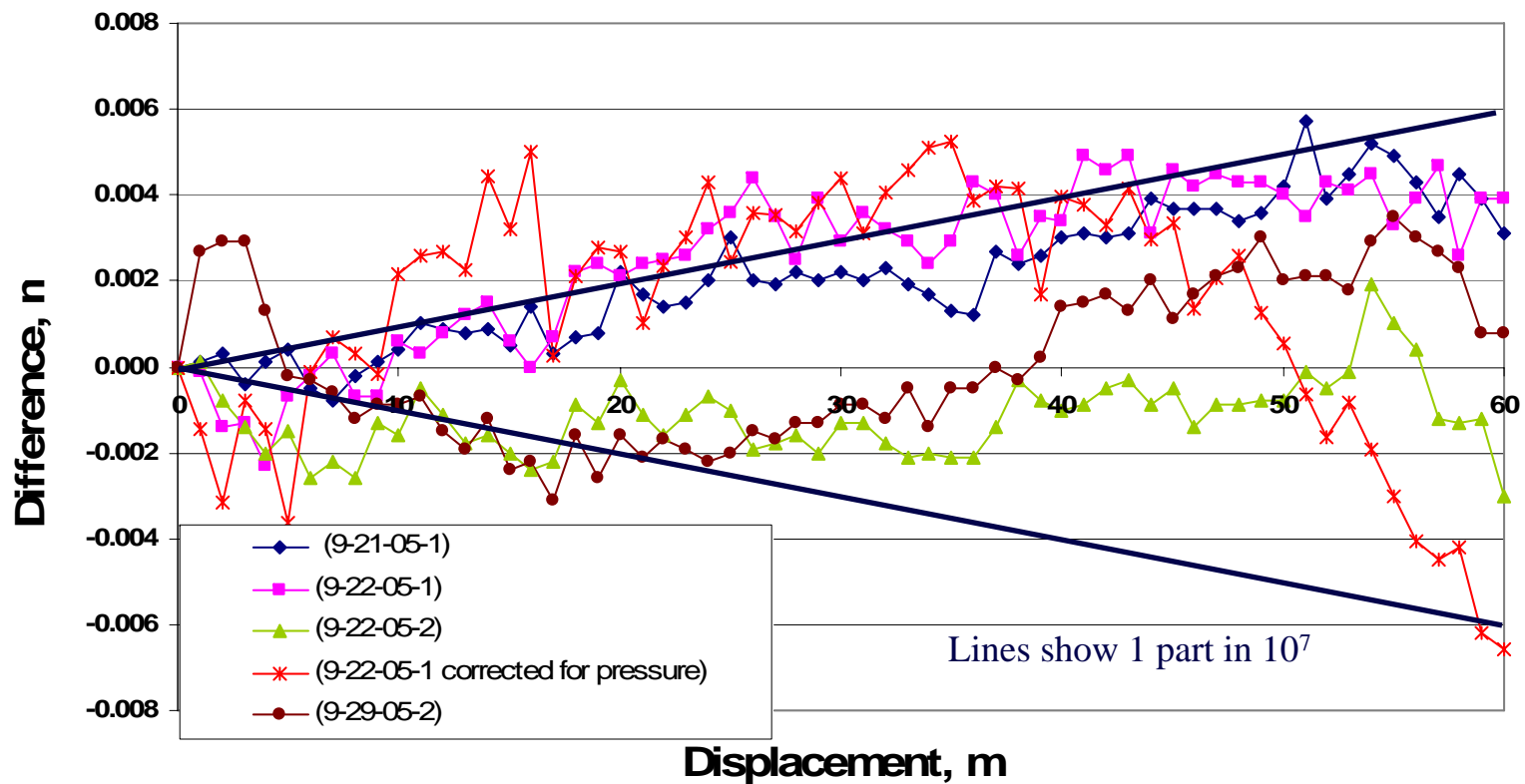
Back-to-Back Comparison



d i m e n s i o n a l m e t r o l o g y

NIST 1-D Range Facility

HP-Renishaw



NIST NonCooperative Target Range

- 65 meters (215')
- 100 mm Dia Ti Spheres with passive reflectance
- 17 Positions

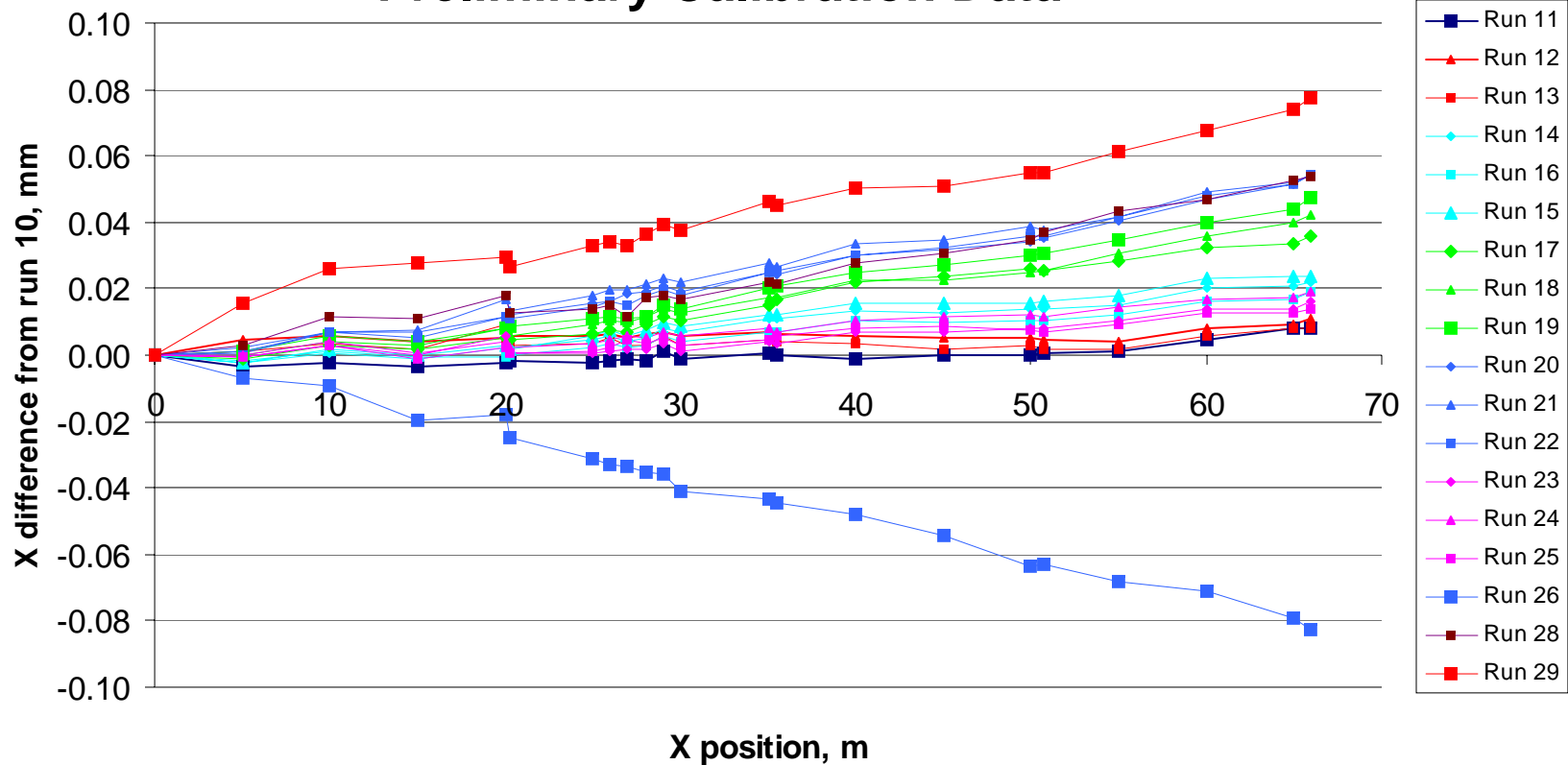


d i m e n s i o

NIST NonCooperative Target Range

X Positions of Monuments- differences

Preliminary Calibration Data



NIST Calibrations

- **1D Range Test: Cooperative Target per B89**
 $U(k=2) = 10 \mu\text{m} + 5 \times 10^{-7} L \mu\text{m}$
(Non-Cooperative Targets also possible)
NIST Calibration Available (\$800)
- **1D Range Test: Non-Cooperative Targets**
100 mm Dia Spheres:
 $U(k=2) = 25 \mu\text{m} + 2 \times 10^{-6} L \mu\text{m}$
NIST Calibration: Coming Soon!
- **Volumetric System Test: Cooperative Target per B89:**
 $U(k=2) = 2 \mu\text{m} + 1.5 \times 10^{-6} L \mu\text{m}$
NIST Calibration Available (\$1000)

Future B89.4.19 Standards work

- Next Meeting:
May 3, 2006 Atlanta GA
- Topic:
NonCooperative Target Systems for
Manufacturing

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Thank you

Q & A

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